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Compare and Contrast Military Vs. Commercial Ground Vehicle Supportability

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ABSTRACT

The Army is actively and forcefully engaged in over 80 countries with approximately 180,000 soldiers operating in various environments with diverse equipment. Approximately 135,000 soldiers are currently operating in Iraq and that number will be sustained through 2005. In order for our soldiers to be effective in their missions, equipment must operate effectively and accurately. However, with current operations our fleets are at a pace ten times that of normal operations (causing entire fleets of trucks and aircrafts need for replacement). The question becomes how does the Army keep up with the demand?

The current supply network, although it is operating at 70% of capacity due to attacks on convoys in Iraq, is keeping pace with the demand. General Kern stated, "We're meeting the requirements but we don't have a lot of slack. If you're in the supply business, you'd like to say you have six months of supplies on the shelf. Right now, we are delivering to meet demands. We are not building any significant reserves." The focus should be how to improve our network to account for the increase demand. This issues falls within the supportability aspect of military operations. Supportability consists of the reliability, training, logistics, and the "Pit Stop Mentality" of a system. This is comparable to the commercial industry that includes manufacturing requirements, training, logistics and ease of maintenance.

The following paper will compare and contrast the military and commercial aspects of supportability, concentrating on the logistic side of supplying parts with respect to contractors and subcontractors. A case study of an M1A2SEP road arms will be evaluated to determine the effectiveness of the current supply system and suggestions for future improvements.

Key Words:
Supportability, Logistics, Supply Chain

INTRODUCTION

Amateurs talk about tactics; professionals talk about logistics. Supportability is the key factor for the success of an Army in the field. Supportability is defined as a measure of the degree to which all resources required to operate and maintain the system/equipment can be provided in sufficient quantity and time [1]. Army Supportability consists of developing systems with pit stop maintainability, high reliability, training the personnel to operate and repair the system in the field versus depot maintenance, and transporting the necessary repair parts and consumables to complete the mission objectives (logistics). Historically, the Army was known for their slow shipments and repairs, and excessive storage of new parts. The past philosophy was if the system was fielded for 20 years, the Army needed to have enough parts to repair the system during that life span and the majority of repairs were completed at the Depot regardless of the vehicle location. Another limitation of the army system was that the majority of parts used on combat vehicles were to military specifications increasing the cost of the part. Who could forget the $200 hammer? In 1995, the National Technology Transfer and Advancement Act began the transformation of Department of Defense (DoD) from using military standards to commercial standards and beginning the change of the slow, big government to one that is becoming a lean cost effective government. Commercial standards opened the door to the Department of Defense using Commercial Off The Shelf products (COTS) reducing the costs of repairs and increasing the ease of manufacturing and the supportability of the systems.

The ability of using COTS products has transformed the Supply Chain process from stocking parts for the entire life span of the vehicle to developing a mathematical formula to determine when the parts should be ordered given the environmental conditions and usage of the system. The COTS transformation is just one part of the entire supply chain process; knowledge management is another key area that has transformed the government. Knowledge management is defined as the entire experience and information on a determined field represented by a set of scientific postulates being in a caused context [2]. The purpose of the knowledge management concept is to allow an assigned Army logistician to see the requirements on the battlefield and have the ability to take corrective action before the failure of the system [13]. The Army has been developing the communications channels as well as the

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prognostic (on board diagnostic) ability to be able to effectively use real time communications with the vehicle system and crew for the future logistic management plan. Presently though, the United States Army is effectively demonstrating the improved supply chain process by supporting 180,000 troops and vehicle systems in over 80 countries with an aging fleet. This is a drastic change from 1991 "Desert Shield", when shipping containers had to be opened to determine the contents and soldiers will attest to eating breakfast rations three times a day because the lunch and dinner rations were lost among the shipments [12]. Although, the Army has drastically improved the supply chain, limitations still exist and are being addressed by the Logistics Management Plan (LMP). The LMP is addressing the ability to respond rapidly and precisely when support requirements are identified, through identification and development of a battlefield distribution system, providing time-definite delivery schedules, and effectively controling physical movements across the new battle environment [13].

This paper will detail the Army's transformation from the lack of supportability of the past into the increasingly effective system of today and the Army's Logistics support of the future. Evidence illustrates that the Army is beginning to transform into a lean enterprise where the public demands more accountability for the spending of taxes much like its commercial counterparts.

Supply Chain Management

For this article, the supply chain will be defined as: the processes from the initial raw materials to the ultimate consumption of finished product linking across supplier-user companies, and the functions inside and outside a company that enables the value chain to make products and provide services to the customer [14].

Army Materiel Command's (AMC) Supply Chain is one of the largest and most complex in the world. It contains $33 billion in munitions stockpiles (conventional weapons and missiles) and $7 billion in secondary items (engines, transmissions and a wide range of other items) that are supplied by more than 50,000 vendors. It is spread across 41 states and 38 countries. During the course of an average year, a million-plus Army customers place more than 8 million orders. AMC comprises 50,000 logistics professionals whose job it is to manage and supply the weapons systems and commodities-artillery, tanks, Army aircraft, missiles, ammunition, field electronics and chemical and biological weapons-protection that are essential to warfighter readiness [15]. The Army has revolutionized the internal supply process to increase the efficiency of the system given the lessons learned from the first Gulf War resulting in the LMP.

The LMP initiated as a working group to investigate the DoD's supply chain and suggest improvements to increase the efficiency of the system. The overall goal of the LMP is to have "Full Spectrum Support" from deployment to redeployment, reconstitution or forward deployment. [11]

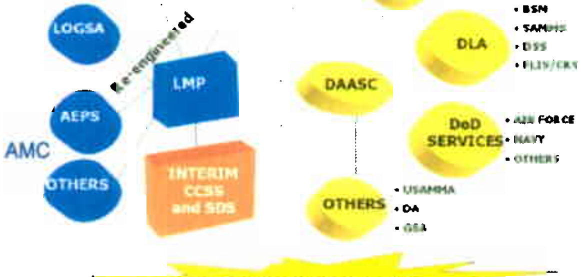

Figure 1: High-Level Architecture of LMP and Interfaces

The working group conducted an investigation of the current system and suggests seven areas needing drastic improvement: Real-Time Single View, Total Asset Visibility, Collaborative Planning, Powerful Forecasting, Predicting Future Usage and Supply Needs, Velocity Management, and Reduced Footprint.

Real-Time Single View stresses the need for the Army to have single data models and standardized item definitions to allow a real time view across the command. Total Asset Visibility is a centralized information storage interfacing with the global transportation network to locate all items in storage, in progress or in transit. The collaborative planning objective is to develop a virtual business warehouse to ensure precise planning and scheduling of vehicle upgrades. Powerful Forecasting integrates all of the Army Materiel Command's financial information. Predicting Future Usage and Supply Needs developed a single system to process orders noting historical usage patterns to optimize future items. Velocity Management is a system develops to implement the suggestions through depot and warfighters alike. Reduced Footprint was key outcome of the LMP. The main idea is through initiating the above methods; it would reduce the need to create "Iron Mountains". "Iron Mountains" are large stockpiles of supplies placed at strategic locations. Although this strategy provided supplies to warfighters, it was inefficient and costly [24]. The key element of the LMP is the outreach to successful commercial industries that specialize in developing supply chains to meet customer needs [15].

The first step of the revolution was Velocity Management implemented in 1995. The objective of Velocity Management was to eliminate the unnecessary steps in the logistics pipeline that caused delay to the parts flow. Velocity Management improved the process of ordering and shipping parts, the repair cycle, inventory levels and locations, and financial Management. The Army began with Velocity Management due to the studies of a commercial airline company British Airlines (BA) that reduced their logistics costs. BA noted that when the company conducted the repairs promptly it reduced delay and the need for more parts. The delay was in part caused by the location and interaction of the repair depots. BA reorganized the repair process and established partnerships with key suppliers as well as used a third-party logistics service to reduce the costs. The study fosters ideas regarding best practices to reduce logistics costs noting that cost reduction occurred when a company: 1) eliminated excess inventory by repairing parts as they break (immediately and not ship parts to a location to be logged and then stored until needed by another aircraft); 2) use the cellular concept to reduce the time to repair parts; 3) increase the availability of parts by utilizing local distribution centers and integrated supplier programs; 4) use a third-party logistics provider to store and distribute spare parts between the depot and end users to improve the delivery time [16]. The Army applied Velocity Management principles at the depot level by reorganizing the procedures and redesigning the locations of the key components of the repair process. The outcome of Velocity Management is an improvement in the speed and accuracy with which materials and information flow from providers to users reducing the need for massive stockpiles [17]. Velocity Management was renamed to distribution Management in 2003.

HIGH RELIABILITY

Reliability is the key to any system and the most difficult to obtain in Industry as well as in Government. Developing a reliable system drastically reduces the logistics footprint and increasing the supportability of the system. Industry has improved the reliability of products through careful control of the manufacturing processes and investigating various relationships between components, electrical as well as mechanical. The Army is also controlling the manufacturing process as well as developing guidelines for designing future weapons systems. The emphasis for supportability is placed on the initial development of the system to include the performance based logistics strategies. Army systems should be developed in such a way that they have the following characteristics: Modularity, Interoperability, Diagnostics, Prognostics, Fail Safe, and Access.

Modularity refers to the development of components and systems with the ability to "plug and play" electrical components, and "remove and replace" mechanical components with respect to ease and efficiency. Interoperability is the ability of the component to be compatible with any standard interface protocols allowing the ease of upgrades through the use of common interfaces. Physical interoperability should be developed such that mechanical parts are only able to be placed in the correct position; the square peg square slot concept. Diagnostics or Built-In-Testing is necessary for any system to accurately monitor and record the system's efficiency and operational capability for fault detection and isolation. Prognostics should be developed to monitor the system and determine possible component failures indicating to the user the need for replacement or maintenance before the failure occurs. The development of a Fail Safe mode such that if the system fails it returns to a previous safe mode to avoid additional damage and secondary failures until the initial failure is addressed. Lastly, all systems should be designed with respect to ease of maintenance or access. Access refers to the ability of technicians to locate and access critical elements for monitoring and maintaining weapon systems [18].

PIT STOP MAINTAINABILITY

The product must be designed for supportability; this includes product manufacturing and product design aspects. Product manufacturing determines how reliable the product is which in turn determines how often it needs to be serviced. This is highly dependent on the engineering capabilities, as higher standards in manufacturing results in less component failures, and less of a need to be supported. As a result, both the military and commercial manufacturers utilize such systems as Six Sigma which benefits both manufacturers and customers: cost saving to the manufacturers and higher quality to the customers.

For example, the M1A2 SEP Abrams tank and M2A3/M3A3 Bradley Fighting Vehicles are equipped with onboard prognostics and diagnostic systems used to monitor in detail the failures and life cycles of various components. This setup allows for on-site maintenance, thus reducing the time from a service depot to the field [3]][4]. However, in the automotive commercial industry there are only a few warning lights for oil or engine checks. Although companies like GM are improving upon these simple concepts with what is called an On-Board Diagnostics II which regularly checks the vehicle emission control systems and an Oil Life System which monitors engine temperature, combustion events, and other parameters to predict the useful life of the oil [5].

Another way to maximize supportability from a logistics standpoint is the ease of maintenance and optimizing the acquisition of spare parts. Ease of maintenance is sometimes referred to as "pit stop engineering," which describes how effectively and efficiently a product can be serviced in the event of product failure [3]. In industry, ease of maintenance has just begun to be incorporated into commercial vehicles. For example, the 2003 Ford trucks advertised that its oil filter is built on top of the engine and can be replaced just like an inkjet printer cartridge [8]. Therefore, everyday customers are educated enough to replace an oil filter. Moreover, the automotive industry recommends that the customer gets the car serviced every 5,000 miles at a dealership or service depot as a routine way to check the vehicle for problems. Military vehicles would only be serviced if their onboard diagnostics and prognostics with automated fault reporting tell mechanics of problems are present, which reduces down time and increases the mean time to repair [3]. As for the military, their pit stop engineering methods have been evolving. For instance, the HMMWV replaced numerous vehicles back in the 1980s as it could take on 15 different configurations with a single design: engine, chassis, and other interchangeable parts. This way, mechanics basically needed to be trained on only one type of vehicle instead of 15 [8]. Moreover, the government recently created a sensor, the Portal Shield Mark III Sensor, which was modularized to such a degree that it could be repaired with no tools in less than 10 minutes.

In terms of technical support, both the commercial industry and military have substantial solutions for their customers. For example, Caterpillar guarantees the delivery of any spare part to anywhere in the world within 48 hours. This capability given to the customer relieves their acquisition concerns and further delays to their work schedules. Further, Hewlett-Packard designed their medical ultrasound device with upgradability. This gives the customer who does not need to purchase a completely new device an option; they could choose to upgrade the software or hardware [8]. In the past decade, the military has begun to use Velocity Management to increase their technical supportability. This system is based on based on readiness and is now able to deliver spare parts in half the time it did a few years ago. For example, "today it takes less time for an Army repair depot to get a spare part from an army supply depot than from a commercial vendor." As a result of Velocity Management which has reduced time of delivery, increased quality and reduced cost of spare parts, repair rates have dramatically increased [6]. Further advances of supportability beyond acquisition include upgradability and on-site manufacturing. Although not originally designed for upgradability, the military has been able to adapt electronic packages for their older vehicles, such as the M1A2 Software Enhancement Package Abrams tank and M1A3 Bradley fighting vehicle [3][4]. Also, just recently deployed in Iraq, the Mobile Parts Hospital has been a huge success as it can create parts in the field without having to procure components to be shipped out.

TRAINING

In order to keep Army mechanics and service technicians up to date with the ever-changing technology and sophistication that is being implemented in ground vehicles, rigorous training and courses are required. A soldier's military training in any area involves 9 weeks of orientation to new way of life, Army values, rigorous physical training, weapons training, basic land navigation and individual tactical training. When specializing in a particular area of ground vehicle training, the soldier must complete 16 weeks of individualized, focused courses in the vehicle to be maintained. During a soldier's advanced individualized training, they will gain the basic knowledge and hands-on skills to perform mechanical maintenance on tanks, small arms weapons, HMMWVs and trucks. While in the Army, soldiers have the opportunity to obtain certification with national technical accrediting agencies, such as the Automotive Society of Excellence (ASE). Additionally, many of these skills also translate into college credit towards a degree [21].

Much like training from both the military and commercial sides, the mechanical repair of the past has evolved to a high technology job. Formal training is vital for the commercial and military side of vehicle repairs because technicians and mechanics form both sides must be able to continually adapt to the ever-changing technology and repair techniques as vehicle components become more electrical and significantly more sophisticated. Auto mechanics and technicians on the commercial side usually attend postsecondary automotive technician training that provide intense career preparation through a combination of classroom instruction and hands-on practice. Some trade schools programs can last from six months to a year, while community college programs typically take two years [22].

While the vehicle maintainer or mechanic must have a fluent understanding of how the various systems and components work together on a particular vehicle, whether it is commercial or military, they must also be able to do so in a timely manner, under certain conditions and within certain environments. For an auto mechanic, it is more feasible to repair a vehicle in less time than a mechanic for the military, because of part availability. An auto mechanic is prone to replace parts or a system of parts because of their availability or ease of obtaining. On the other hand, a military mechanic or soldier will have to have a further specialized training and have a more in depth understanding of the part or component that has failed on a vehicle. This is because the military mechanic must be able to repair or manipulate a part to work properly because there are a limited number of supplies when in the field. For example, an M-1 Abrams Tank System Maintainer is responsible for supervising and performing standard maintenance on Abrams tanks, which consists of the following: performing major assembly replacement including turret and fire control systems, diagnosing and troubleshooting malfunctions, performing organizational maintenance and on-board direct support tasks on the suspension systems, steering systems, and hydraulic systems, repairing Abrams weapon systems and infantry weapons, and testing and adjusting weapons firing, guidance and launch systems [23]. There are various components on the vehicle that could potentially fail. Not only do the soldiers have to maintain the components and systems that will keep the tank running properly, they have to maintain additional infantry weapons and their firing, guidance, and launch systems.

In addition, an auto mechanic may have assistance or the guidance of other associates when repairing a vehicle, while a military mechanic has little assistance if any when working in the field. Different environmental conditions must be taken into consideration when contrasting the commercial and military side of supportability of ground vehicles. While an auto mechanic has a garage or repair shop to work on vehicles, soldiers do not always have this luxury. They must train to be outside in the artic snow and cold, or the desert heat and sand. It is with these military needs that a soldier must be trained to try to maintain a peak performance on their vehicle at all times so that their mission can be completed in a timely manner.

LOGISTICS

The previous sections have discussed the transformation of the Army's concept development stage including Pit Stop Engineering, and in general the supply chain. The last key component of supportability is logistics. Industry has shifted much of the responsibility of supply chain and interrelationships along to the Tier 1 suppliers by requiring total vehicle systems integration and parts innovation and product life cycle management while the government is still managing in house [19]. The Defense Logistics Agency (DLA) manages 80% of the parts required to maintain the readiness and operational availability of weapon systems [20]. DLA has developed a system to identify three levels of priority for the speed at which requests are handled and parts are shipped to reduce down time of critical systems. They have created portals where the warfighter can locate, order, and ship available parts directly from the facility it is housed at. The development of the portal has reduced the need for the warfighter to order duplicate parts in case an order is lost.

Lastly, using historical records, logisticians have identified key areas that need to be improved to reach the next level of interoperability, Focused Logistics (FL) (figure 1). FL objective is to have full spectrum supportability defined as supporting the warfighter from a source of supply to a point of need whether that is a foxhole, cockpit, deck plate, or base. Focus Logistics identifies the need to simultaneously evaluate the criteria in order to efficiently support the warfighter.

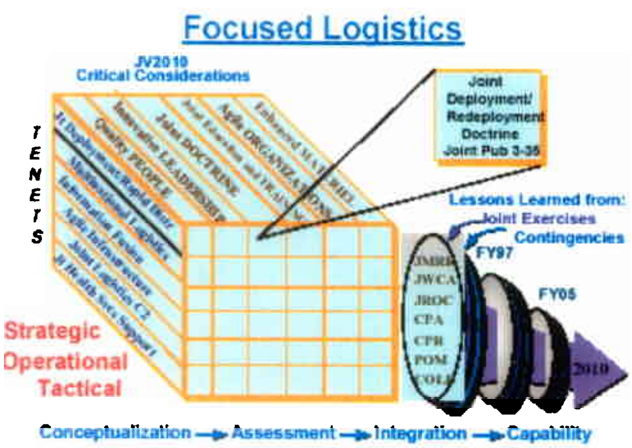

Figure 2: Focused Logistics and the "Six Critical Considerations of JV 2010"

M1A2 ROAD ARMS CASE STUDY

The case study focuses on the improvements the Army has developed and implemented within the supply chain. It will focus on the procedure that is in place for the program managers of legacy systems detailing the continuous improvement of legacy systems with respect to safety and supportability. Specifically, the case study will focus on the Abrams M1A2 and M1A2 SEP systems and a recent failure that resulted in a technical engineering change during Operation Iraqi Freedom.

For over 14 years, Team Abrams has worked to improve the safety, reliability, maintainability, and performance of the Army's Main Battle Tank and Heavy Assault Bridge. The Abrams (M1A2) was manufactured by General Dynamics (Land Systems Division). It contains a 4 man crew (commander, gunner, loader, and driver), weighs approximately 70 Tons, and has a ground clearance of 19 inches. The M1A2 is a tracked vehicle able to cross an obstacle 42 inches across and a vertical trench of 9 feet. The maximum speed is 42 mph on standard roads; 30 mph cross country, and has a cruising range of 265 miles with respect to fuel capacity.

Figure 3: M1A2 Abrams

The M1A2 is one of our nation's most lethal fighting system with a 120mm M256 Smooth Bore Cannon, 0.50 caliber M2 machinegun, and 7.62 M240 Machinegun on Skate mount. The tank houses 40 rounds of the main gun, 1,000 rounds of the commander's 50 caliber, 10,800 rounds of M240 7.62 MG, and 24 rounds of smoke grenades. The M1A2 has the honor and distinction of being the system to conduct the longest land march in the Marines' 228 year history. It traveled 500 cruel, dusty miles from northern Kuwait to Baghdad in 5 weeks through the desert, on primary as well as secondary roads during conflict.

The M1A2 main battle tank was truly tested on all accounts. The sand storms tested the redesigned pre-cleaner on the air induction system and the PulseJet Air System (PJAS); they tested the training of all soldiers on the maintenance and inspections required on the fuel, hydraulic, and Nuclear, Biological, and Chemical (NBC) systems to prevent engine fires; they tested the newly modified transmission valve body. These corrective actions were all developed prior to the Road to Baghdad by the Field Problem Review Board (FPRB). The FPRB has the mission of continuously monitoring reports from the field and from test sites to identify any problems affecting the safety, reliability, availability, maintainability, and performance of the Abrams [25].

The FPRB meets in Warren, Michigan every second month and is composed of design and safety engineers, reliability and maintainability specialists, quality assurance engineers, logisticians, managers, and military representatives from Team Abrams. The FPRB is currently tracking 25 problems with the fleet, has a database of 18,000 field problem reports and over 68,000 test problem reports.

The success of the FPRB is dependent on the soldier. The first step in the process is a soldier identifying a recurring problem with a part or system on the tank. Then a Field Service Representative (FSR) is notified and investigates the report. The FSR then filters a report to the Field Management Cell that contains all service reports and analyzes the reports to note any trends. The reports and trends are then identified at the FPRB to determine corrective actions. However, an equally critical component of the FPRB process is the logisticians. They constantly monitor the supply system demands noting increased demands on specific items that are inconsistent with the expected usage.

The FPRB process is as successful as the individuals that take the time to report and investigate the high rate of failure. PM Abrams noted a high rate of road wheel spindle failures (480) occurring on the Abrams M1A2 and M1A2 Special Enhancement Package (SEP) in Iraq and initiated an investigation into the cause of the failure. The investigation team organized the 76 failure reports that noted the miles-at-failure into a distribution pattern. They determined that the number of miles to failure appeared to be uniformly distributed, indicating that an unidentified vehicle operational mode was causing the failures and not that the vehicles were experiencing a critical-life-mileage failure. The next step was for the Program Management Office (PM) to ship failed spindles from Iraq to conduct a failure analysis. The investigating team consisting of experts in engineering materials, suspension and hardware design.

The conclusion of the investigation was that the road arm lower spindles failed by low load, high cycle fatigue. The corrective action was to localize induction hardening of the spindle to a specific hardness profile in the area of weakness. Although corrosion reduces the life expectance by 20% and is not a major contributor to the failure, a sealant was added to the new design to avoid corrosive pitting in the future. The new spindle design has 10 times the life of the current system. The solution demonstrates the improvements that the Army is demonstrating with the Life Cycle Management Process. The key to the successful outcome was integration between knowledge management and supply chain management viewed by PM to improve the M1A2 Abrams.

CONCLUSION

The Army has taken successful strides towards a more efficient management style by reorganizing the supportability of future and legacy assets by developing guidance for key supportability elements of future systems, creating a supply chain that improves the efficiency of repairing and ordering replacement parts, and integrating it across all levels of the command with a free flow of commutation and information. It is recognized that the automotive industry is initiating globalization and competition in information and communication. However, lessons learned from the government sector have led to many product developments that aid in supply chain management. Although the Army is changing, change is notoriously slow and valuable lessons are learned through our Industry partners. It is without a doubt that the LMP will continue to grow and become more efficient such that in the future logisticians and warfighters will be able to depend on the integrated system to communicate the needs with limit input from the soldiers.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

[1] BA-British Airways

[2] CSCC-Commodity Command Standards System

[3] COTS –Commercial Off The Shelf

[4] LMP - Logistics Management Plan

[5] AMC – Army Materiel Comman

[6] DoD – Department of Defense

[7] BA – British Airways

[8] DLA – Defense Logistics Agency

[9] PJAS – PulseJet Air System

[10] FPRB – Field Problem Review Board

[11] SDS-Standard Depot Systems

[12] SEP - Special Enhancement Package